United States Environmental Protection Agency | National Risk Management Research Laboratory Cincinnati, OH 45268
Research and Development | EPA/600/SR-02/076 | August 2004

EPA

Project Summary

Emissions of Organic Air Toxics from Open Burning

Paul M. Lemieux

Emissions from open burning, on a mass pollutant per mass fuel (emission factor) basis, are greater than those from well-controlled combustion sources. Some types of open burning (e.g., biomass) are large sources on a global scale when compared with other broad classes of sources (e.g., mobile and industrial sources). A detailed literature search was performed to collect and collate available data on emissions of airborne toxic organic substances from open burning sources. Data available in the literature varied according to the source and class of air toxics of interest. Volatile organic compound (VOC) and polycyclic aromatic hydrocarbon (PAH) data were available for many of the sources. Data on emission of semivolatile organic compounds (SVOCs) that are not PAHs were available for several sources. Carbonyl and polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofuran (PCDD/F) data were available for only a few sources, and there were several sources for which no emissions data were available at all. Several observations were made from the available data.

- **On a mass emitted per mass burned basis, less VOCs were typically emitted from biomass open burning sources than from those with anthropogenic fuels, particularly fuels containing polymers.**
- **Biomass open burning sources typically emitted less SVOCs and PAHs than anthropogenic sources, on a mass emitted per mass burned basis. Burning pools of crude oil and diesel fuel produced significant amounts of PAHs relative to other types of open burning, and PAH emissions were highest when combustion of polymers was taking place.**
- **Based on very limited data, biomass open burning sources typically produced higher levels of carbonyls than anthropogenic sources on a mass emitted per mass burned basis, probably due to oxygenated structures resulting from thermal decomposition of cellulose.**
- **It must be noted that local burn conditions could significantly change these relative levels.**
- **Based on very limited data, PCDD/F emissions varied greatly from source to source and exhibited significant variations within source categories. This high degree of variation is likely due to a combination of factors, including fuel composition, fuel heating value, bulk density, oxygen transport, and combustion conditions. This highlights the importance of having acceptable test data for PCDD/F emissions from open burning to better quantify contributions of those sources to the overall PCDD/F emissions inventory.**

This Project Summary was developed by the National Risk Management Research Laboratory's Air Pollution Prevention and Control Division, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The purpose of the report is to 1) enumerate types of open burning activities and the availability of organic air toxics emissions data; 2) identify methodologies for developing open burning air toxics emissions data, including methods for measuring emissions and converting the data into forms useful for emissions inventory development and source emissions comparisons; 3) compare emissions of different organic air toxic pollutants within open burning source classifications on a per mass of material burned basis; and 4) compare emissions of different organic air toxic pollutants from open burning in general on a per mass of material burned basis.

A detailed literature search was performed to collect and collate available data on emissions of organic air toxics from the target open burning sources listed in Table 1. Data available in the literature varied according to the source and the class of air toxics of interest. Volatile organic compound (VOC) and polycyclic aromatic hydrocarbon (PAH) data were available for many of the sources. Data on emission of non-PAH semivolatile organic compounds (SVOCs) were available for several sources. Carbonyl and polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofuran (PCDD/F) data were available for only a few sources, and there were several sources for which no emissions data were available at all.

Table 1. Open Burning Sources

Accidental Fires
Agricultural Crop Residues
Agricultural Plastic Film
Animal Carcasses
Automobile Shredder Fluff
Camp Fires
Car/Boat/Train Fires (cargo excluded)
Construction Debris
Copper Wire Reclamation
Crude Oil and Oil Spill Fires
Electronic Waste
Fiberglass
Fireworks
Grain Silo Fires
Household Waste
Land Clearing Biomass Debris
Landfills/Dumps
Prescribed Burning/Savanna/Forest Fires
Structural Fires
Tire Burning
Yard Waste Burning

Summary and data analysis

Table 2, the summary of available data, shows that some of the targeted sources covered in the report are better characterized than others, some are poorly characterized, and some are not characterized at all. Thus, data available in the literature permits comparison of only 10 of the original 21 target source categories. Because the collected data is not a robust set, it is not possible to directly compare speciated organics as a whole from the various sources. Rather, the report compares sources by selecting certain key pollutants within general pollutant classes. Measurements of these key pollutants within sources were averaged so that a single value could be used for that source. Where sufficient data are available, error bars have been added to illustrate the range of emission values for that source.

Benzene, toluene, ethyl benzene, xylenes, and styrene are the key pollutants selected for comparison of VOCs. They are commonly produced during combus-

Table 2. Summary of Available Data

Pollutant	Prescribed Burning/Savanna/Forest Fires	Agricultural Crop Residues	Land Clearing Biomass Debris	Yard Waste Burning	Camp Fires	Animal Carcasses	Crude Oil and Oil Spill Fires	Accidental Fires	Household Waste	Landfills/Dumps	Tire Burning	Automobile Shredder Fluff	Fiberglass	Agricultural Plastic Film	Structural Fires	Car/Boat/Train Fires (cargo excluded)	Construction Debris	Grain Silo Fires	Copper Wire Reclamation	Fireworks
VOCs	X	X	X				X		X		X	X	X	X						
SVOCs/PAHs	X	X	X	X			X		X		X	X	X	X						
Carbonyls	X	X					X		X											
Total PCDDs/Fs	X	X					X		X			X								
TEQ[a] PCDDs/Fs	X	X							X											
Total PCBs									X											
TEQ PCBs									X											

[a] TEQ = toxic equivalent

tion processes, and data were available for most of the ten comparison sources. Figure 1 shows the relative quantities of these key VOCs produced across those comparison sources for which data were available. The biomass sources generally had less VOC emissions than the other sources. In particular, sources with significant amounts of polymer plastics (automobile shredder residue, fiberglass) produced fairly prodigious amounts of VOCs, approaching percent levels of the initial material mass. Pesticide bags, although made from plastics, did not show emissions as high as other sources containing large quantities of plastics. It is possible that ambient air influx was sufficient in the pesticide bag experiments to allow more efficient combustion of the material.

For the SVOCs, naphthalene, benzo[a]pyrene, and total non-naphthalene PAHs were chosen for comparison. It must be noted that, for agricultural burning, naphthalene was not included because of the reference's authors' doubts on the quality of the data. Figure 2 compares the emissions of the selected key SVOCs from the various sources. As was the case with the VOCs, the combustion of biomass produced less SVOCs than combustion of various man-made products. Pool fires of liquid fuels produced significant amounts of PAHs, but tire fires and combustion of fiberglass produced the most. Tire fires produced nearly 100 mg of benzo[a]pyrene per kg of tire combusted.

The available data for carbonyls is much more limited, so formaldehyde was chosen as the only compound for comparison between sources. Figure 3 illustrates the relative emissions of formaldehyde from open burning. Although the data set is much more limited than for VOCs and SVOCs, it shows that combustion of biomass produced significantly more formaldehyde than the other open burning sources. This is likely due to the high levels of elemental oxygen bound within the cellulose structures found in biomass.

Emissions of PCDDs/Fs showed significant differences between somewhat similar sources. As can be seen in Figure 4, open burning of agricultural residues such as wheat and rice straw produced almost two orders of magnitude less PCDDs/Fs per kg of material burned than forest fires, on both a total and a TEQ basis. Open burning of household waste in barrels shows similar emissions to that of forest fires. Automobile shredder residue emitted several orders of magnitude higher PCDDs/Fs than any of the other

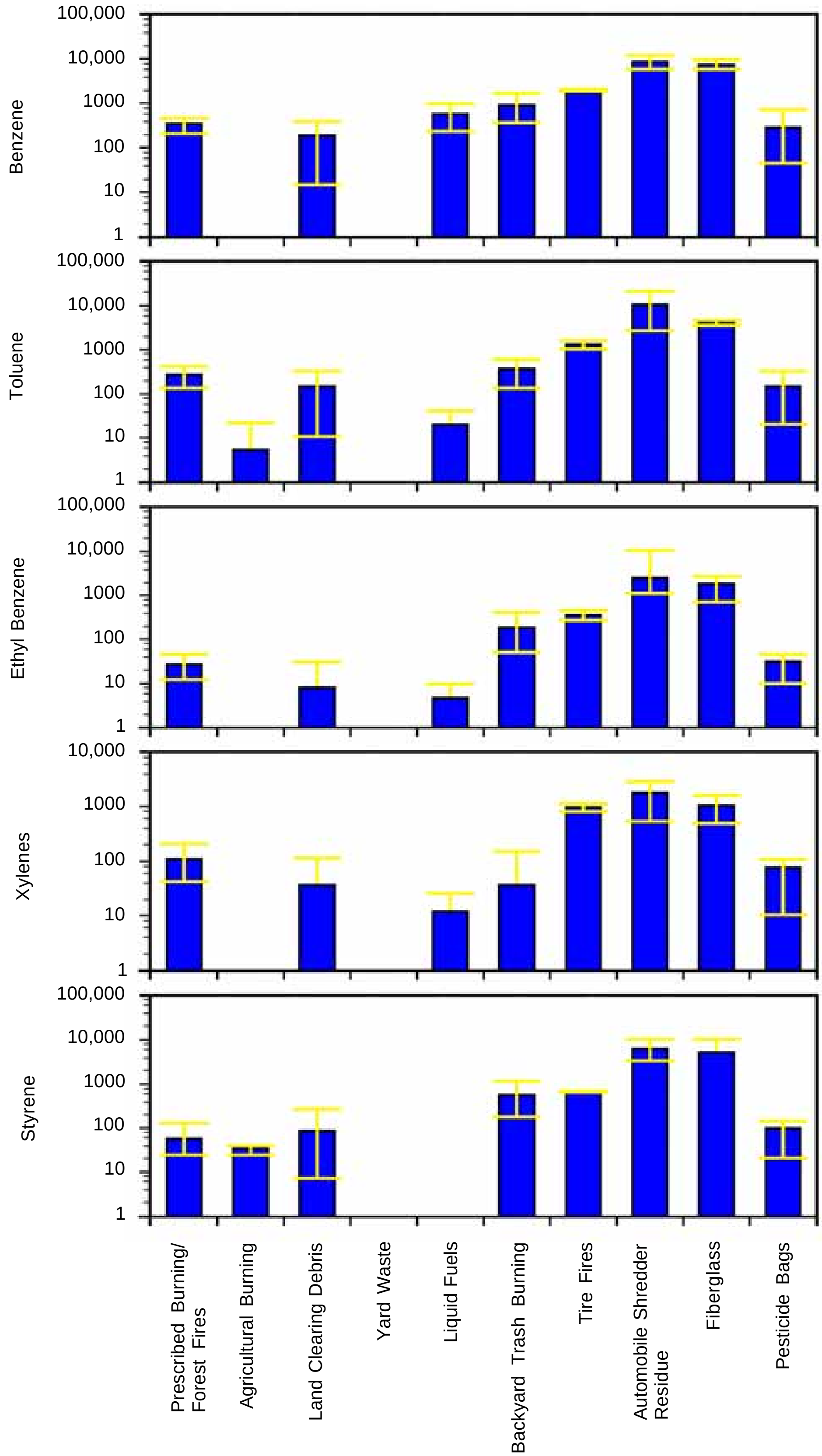

Figure 1. VOCs from Open Burning Sources (mg/kg burned material)

sources, likely due to the smoldering combustion that occurred during the fluff combustion experiments. This is consistent with the backyard burning experiments, which found that higher levels of PCDDs/Fs were produced during the smoldering combustion stage than during flaming combustion. Automobile shredder fluff contains significant amounts of copper (from shredded electrical components) and chlorine (from vinyl seat cushions), which are consistent with formation of PCDDs/Fs. Given the high degree of inter- and intra-source variability, it is not likely that PCDD/F emissions could be estimated with even a poor degree of certainty without the presence of test data.

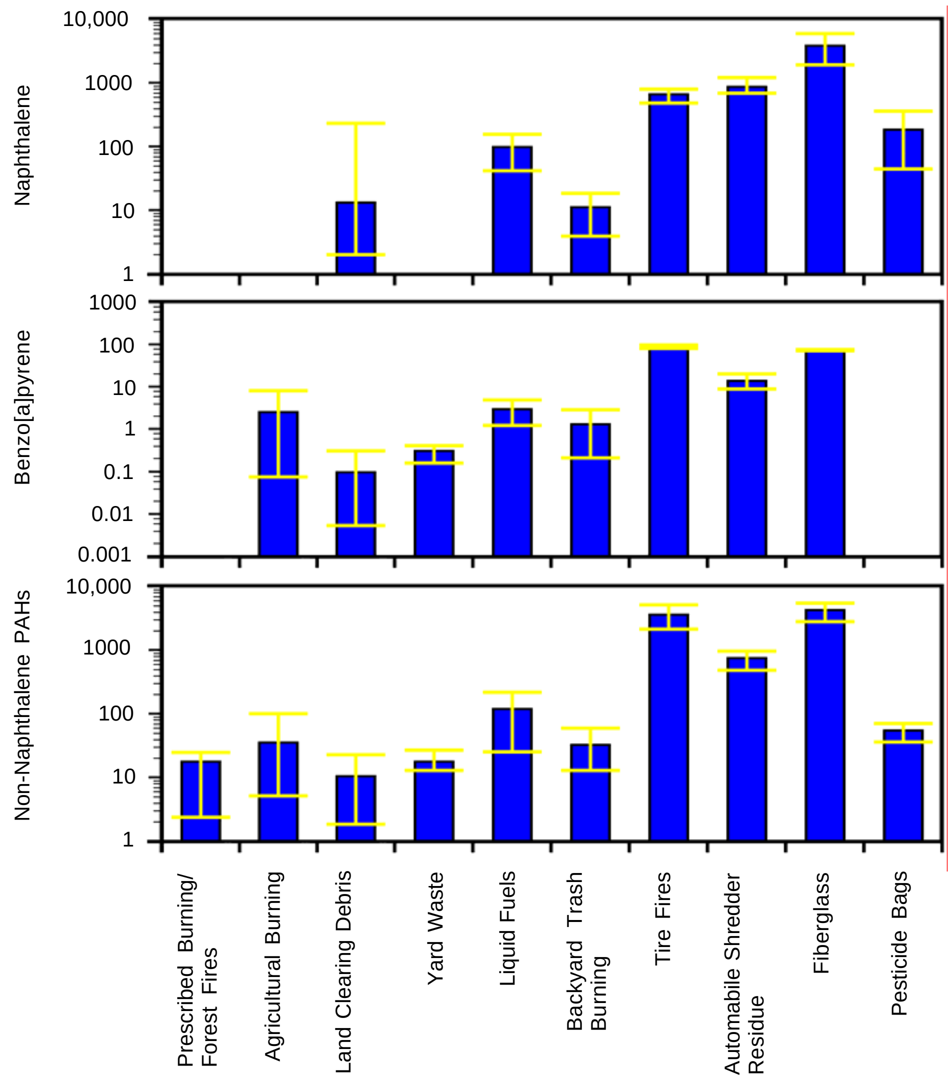

Figure 2. SVOCs from Open Burning Sources (mg/kg material burned)

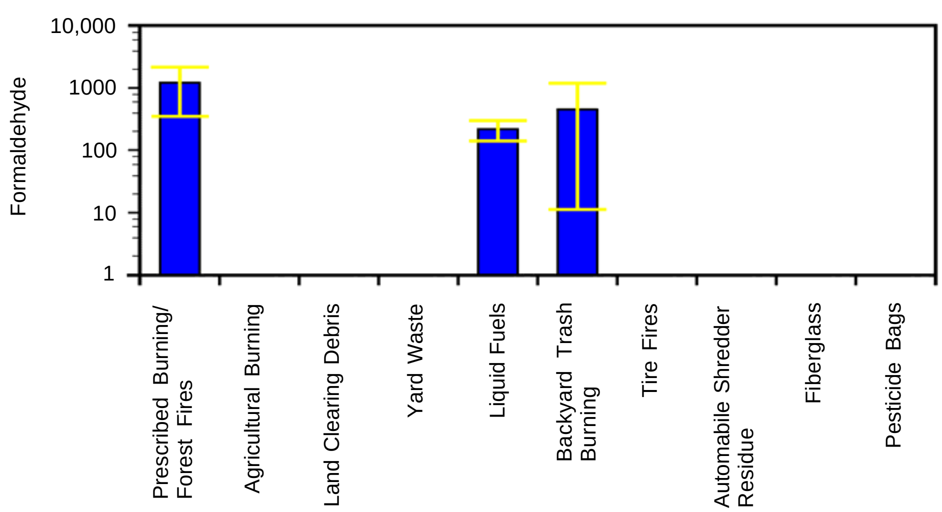

Figure 3. Formaldehyde from Open Burning Sources (mg/kg material burned)

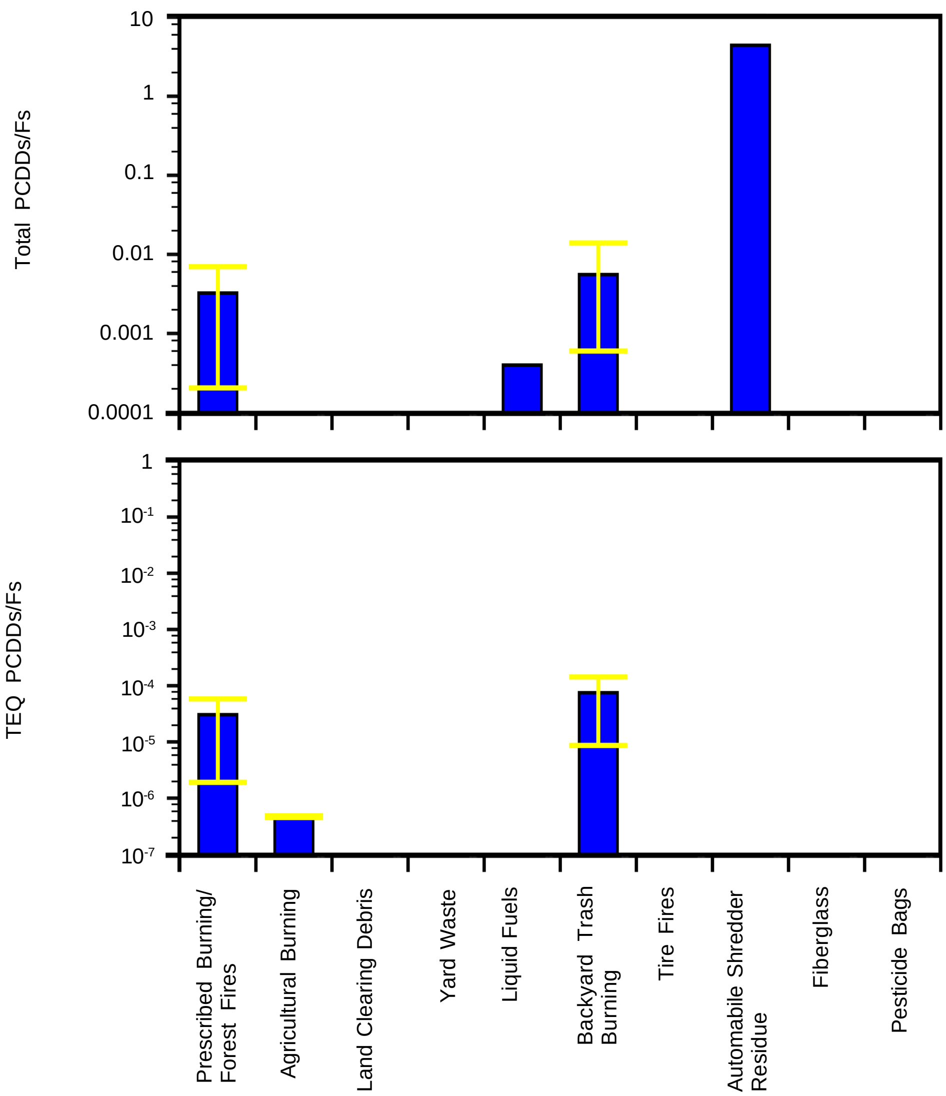

Figure 4. PCDDs/Fs from Open Burning Sources (mg/kg material burned)

*The EPA author, **Paul M. Lemieux** is also the EPA Project Officer (see below).*
*The complete report, entitled "Emissions of Organic Air Toxics from Open Burning," is available at **http://www.epa.gov/appcdwww/aptb/EPA-600-R-02-076.pdf** or as Order No. PB2004-106605; Cost: $31.50, subject to change from:*

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161-0001
Telephone: (703) 605-6000
(800) 553-6847 (U.S. only)

The EPA Project Officer can be contacted at:

Air Pollution Prevention and Control Division
National Risk Management Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711-0001

United States
Environmental Protection Agency
Center for Environmental Research Information
Cincinnati, OH 45268

PRESORTED STANDARD
POSTAGE & FEES PAID
EPA
PERMIT No. G-35

EPA/600/SR-02/076